Parallel Electric Field-Dependent Mobility

Saturation Velocity Model

As carriers are accelerated in an electric field their velocity will begin to saturate when the electric field magnitude becomes significant. This effect has to be accounted for by a reduction of the effective mobility since the magnitude of the drift velocity is the product of the mobility and the electric field component in the direction of the current flow. The following Caughey and Thomas Expression [41] is used to implement a field-dependent mobility. This provides a smooth transition between low-field and high field behavior where:

$$\mu_n(E) = \mu_{n0}\left[\frac{1}{1+\left(\frac{\mu_{n0}\,E}{\mathrm{VSATN}}\right)^{\mathrm{BETAN}}}\right]^{\frac{1}{\mathrm{BETAN}}} \quad 3\text{-}286$$

$$\mu_p(E) = \mu_{p0}\left[\frac{1}{1+\left(\frac{\mu_{p0}\,E}{\mathrm{VSATP}}\right)^{\mathrm{BETAP}}}\right]^{\frac{1}{\mathrm{BETAP}}} \quad 3\text{-}287$$

Here, E is the parallel electric field and μ_{n0} and μ_{p0} are the low-field electron and hole mobilities respectively. The low-field mobilities are either set explicitly in the MOBILITY statement or calculated by one of the low-field mobility models. The BETAN and BETAP parameters are user-definable in the MOBILITY statement (see Table 3-59 for their defaults).

The saturation velocities are calculated by default from the temperature-dependent models [241]:

$$\mathrm{VSATN} = \frac{\mathrm{ALPHAN.FLD}}{1+\mathrm{THETAN.FLD}\,exp\left(\frac{T_L}{\mathrm{TNOMN.FLD}}\right)} \quad 3\text{-}288$$

$$\mathrm{VSATP} = \frac{\mathrm{ALPHAP.FLD}}{1+\mathrm{THETAP.FLD}\,exp\left(\frac{T_L}{\mathrm{TNOMP.FLD}}\right)} \quad 3\text{-}289$$

But, you can set them to constant values on the MOBILITY statement using the VSATN and VSATP parameters.

In this case, no temperature dependence is implemented. Specifying the FLDMOB parameter on the MODELS statement invokes the field-dependent mobility. FLDMOB should always be specified unless one of the inversion layer mobility models (which incorporate their own dependence on the parallel field) are specified.

You can invoke a C-INTERPRETER function for the saturation velocities. The F.VSATN and F.VSATP parameters in the MATERIAL statement can be set to provide the filenames of two text files containing the particular functions. These functions allow you to include the temperature dependence. See Appendix A "C-Interpreter Functions" for more details.

Canali Modification

The Canali model [39] has been implemented as an alternative to using fixed values of BETAN and BETAP in the Caughey-Thomes model. This uses the exponent BETA, which depends on lattice temperature (TL), and will calculate the values of BETAN and BETAP as

$$\mathrm{BETAN} = \mathrm{N.BETA0}*(TL/300)^{(\mathrm{N.BETAEXP})} \tag{3-290}$$

$$\mathrm{BETAP} = \mathrm{P.BETA0}*(TL/300)^{(\mathrm{P.BETAEXP})} \tag{3-291}$$

The Canali model can be used for Silicon up to 430 K.

To enable the model, use the N.CANALI and P.CANALI parameters on the MOBILITY statement. You should also set the FLDMOB flag on the MODELS statement. The EVSATMOD and HVSATMOD should also have their default values of 0.

Table 3-59 User-Definable Parameters in the Field-Dependent Mobility Model

Statement	Parameter	Default	Units
MOBILITY	ALPHAN.FLD	2.4×10^7	cm/s
MOBILITY	ALPHAP.FLD	2.4×10^7	cm/s
MOBILITY	BETAN	2.0	
MOBILITY	BETAP	1.0	
MOBILITY	N.BETAEXP	0.66	
MOBILITY	N.BETA0	1.109	
MOBILITY	N.CANALI	False	
MOBILITY	P.BETAEXP	0.17	
MOBILITY	P.BETA0	1.213	
MOBILITY	P.CANALI	False	
MOBILITY	THETAN.FLD	0.8	
MOBILITY	THETAP.FLD	0.8	
MOBILITY	TNOMN.FLD	600.0	K
MOBILITY	VSATN		cm/s
MOBILITY	VSATP		cm/s
MOBILITY	TNOMP.FLD	600.0	K